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A3B
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(54) Protective footwear

(57) A boot for protection against subjacent explosive blast includes a platform sole (1) having a blast deflector (7) in the form of an isosceles triangular prism which is disposed between the upper and lower faces 6, 5 of the sole 1 and which extends apex downwards substantially the length of the sole 1, its base (8) extending substantially the length and width of the sole 1.

The deflector 7 is preferably formed from a fibre reinforced plastic composite, and preferably includes two mirror-image right angled triangular prisms filled with energy absorbent material 25 and wound with laminates 40, 41, of resin impregnated fabric.

The deflector 7 includes a vertical brace 23 and a metal capping strip 24 adjacent its apex. The deflector 7 is embedded in a moulded readily disruptable material 26 of the sole 1. The sole 1 is bonded to the overboot shell 2 which is also fabricated from laminates 50 of resin impregnated fabric. Overboot straps 3 are interleaved with the laminates 50.

Fig.3.

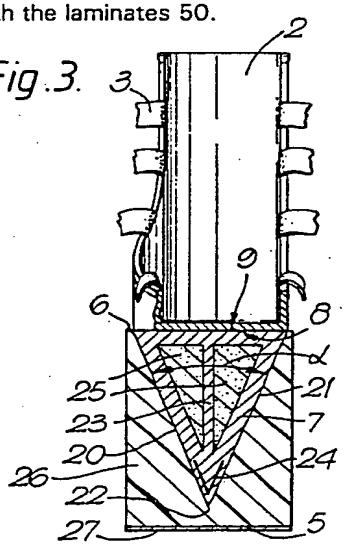
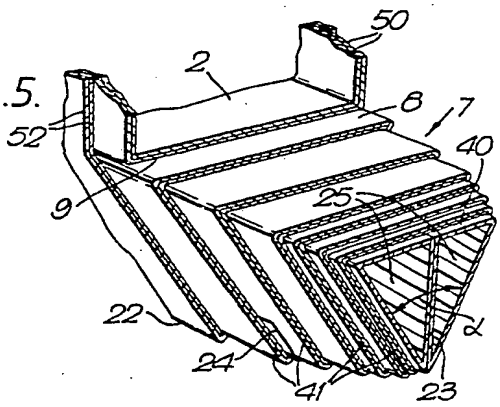


Fig.5.



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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

Fig.1.

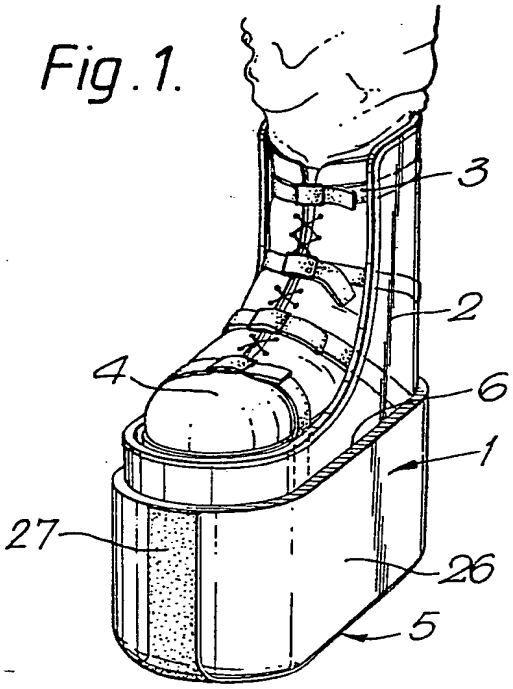

Fig.2.

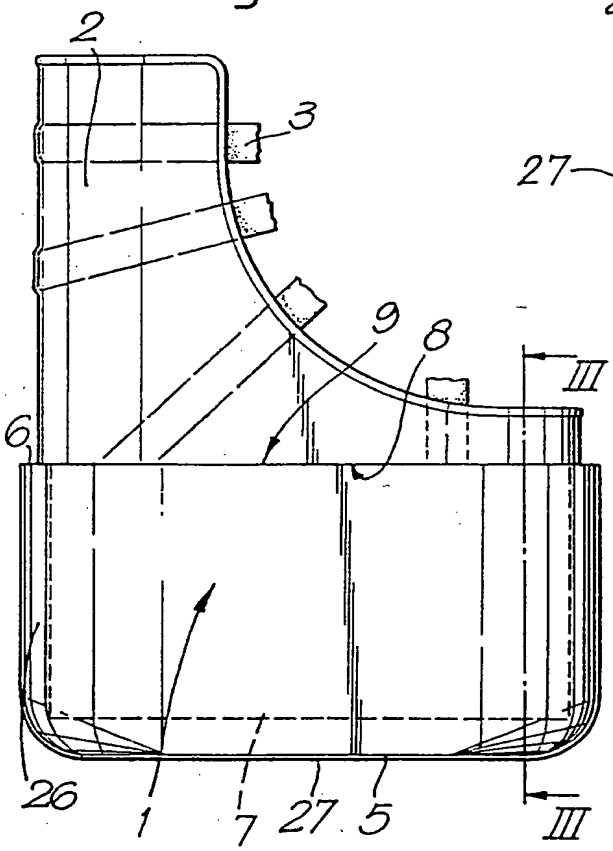

Fig.3.

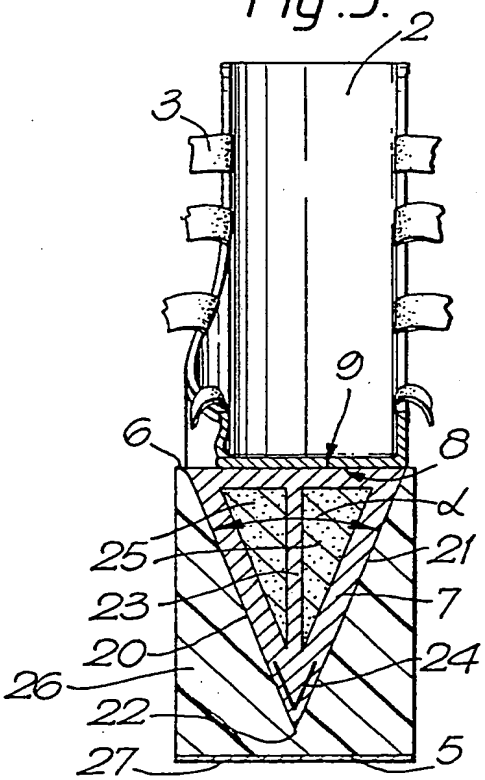

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Fig.4.

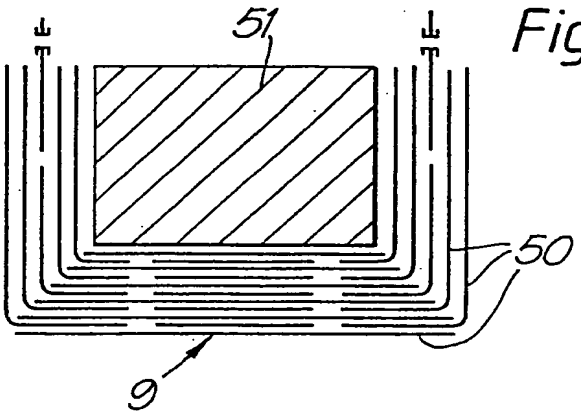


Fig.5.

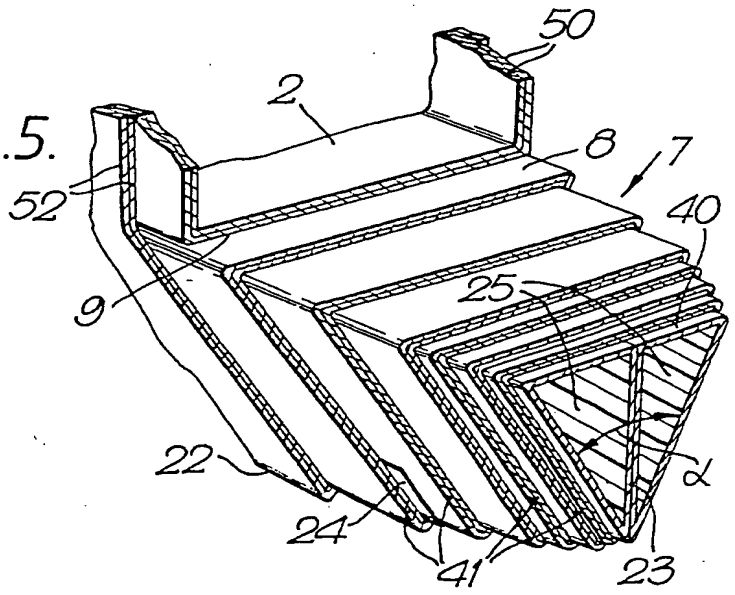
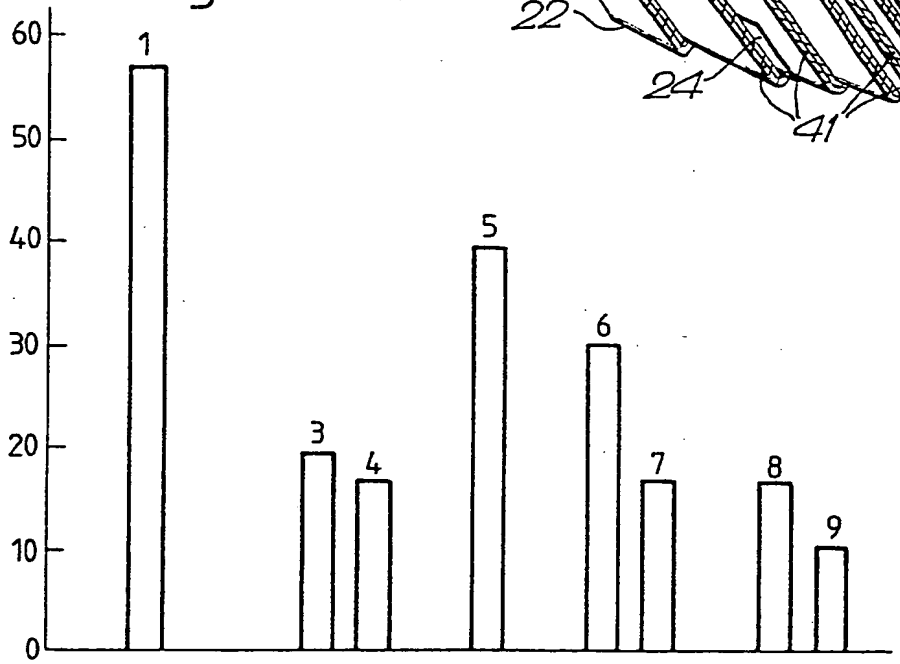


Fig.6.



SPECIFICATION

Protective footwear

This invention relates to protective footwear for personnel engaged in the clearance of anti-personnel mines.

Various boots are known for protecting a wearer from underlying mines which depend upon the principle of spreading the wearer's load so as to minimise the chance of detonation. However these boots, which incorporate load spreading surfaces such as extended ski-like soles or air bags, provide no protection whatsoever if a mine does become detonated.

One boot that is known for the protection of the user in the event of a mine detonation incorporates a metal counter and a half insole extending around and beneath the wearer's heel, beneath which is located a "V"—section deflector plate having an included angle of approximately 110°, disposed apex downwards so as to extend parallel with the longitudinal axis of the insole. The region between the deflector plate and the metal half insole is filled with an energy absorbent, aluminium honeycomb. This boot provides only very limited and dubious protection, the honeycomb compressing all too readily after absorbing only a small proportion of the blast energy released by any but the smallest of anti-personnel mine charges, and thereafter allowing the deflector plate to penetrate upwards through the metal insole. Consequently the boot not only fails to give adequate protection but introduces an additional fragmentation hazard. The boots are also highly undesirable in providing a wearer with a false sense of security.

The present invention seeks to provide protective footwear which can be relied upon at least to limit any injury received by the wearer to a repairable level, ie one at which no limb amputation would ensue.

According to the present invention, footwear for protection against subjacent explosive blast includes a platform sole having an upper face, a substantially parallel lower face and a blast deflector disposed therebetween, the blast deflector being comprised by a triangular prism having a base located adjacent the upper face so as to extend longitudinally through substantially the full length of the sole and laterally through substantially the full width of the sole, the prism being of isosceles cross-section having two equi-length sides directed downwardly towards an apex, which apex extends longitudinally adjacent the lower face.

The apex angle of the blast deflector prism is desirably no greater than 90°, ie each side face inclined at no less than 45° from the horizontal, so as to minimise retroreflection of the vertical component of blast force generated by an underlying explosion.

Preferably the apex angle is even narrower than 90° so as to increase the inclination of the two deflecting surfaces from the horizontal, thereby to lengthen the initial impact period of the vertical blast component. A narrower apex angle is also advantageous in increasing the stand-off distance of the upper face from the ground. Thus, the narrower the apex angle, the better is the protection achieved within the limitation that the spatial prism subtended by the angle will still encompass the wearer's body. The increased platform height will of course engender problems of stability for the wearer and an apex angle within the range 50° to 45° has been found to give effective protection compatible with walking convenience and comfort.

The prism may be either solid or hollow and formed from a metal or a plastics composite, the composite being preferred both for lightness of weight and avoidance of interference with metal sensors that may need to be used by the wearer or by other persons in the vicinity for mine detection.

In a preferred arrangement, the composite prism is tubular to reduce weight as much as possible and incorporates a multiplicity of hoop-wound, circumferential fibres. For additional strength, the composite prism may also incorporate a multiplicity of longitudinal fibres and such prism may be conveniently formed by winding a resin impregnated woven fabric of the fibres around a suitable former. The former used may be of a lightweight, energy absorbent material which may advantageously remain within the prism.

Additionally the tubular composite prism may advantageously include a "T"-brace extending perpendicularly between the base and the apex. A further advantageous addition is the inclusion of a metal capping strip bonded into the composite adjacent to the outer length of the apex so as to improve flash resistance.

The platform sole may comprise the sole of a purpose-made boot or may alternatively be attached to an overboot shell suitable for wearing over conventional footwear. Preferably the shell is rigid and extends above the ankle at the sides and back to support the ankle for walking and to protect from flying fragments, fixing means such as, for example, laces or straps being provided for attaching the shell firmly to the boot and leg.

An embodiment of the invention will now be described by way of example only with reference to the attached drawings of which

Figure 1 is a perspective view of the platform sole arranged as an overboot,

Figure 2 is a side view of the overboot illustrated in Figure 1,

Figure 3 is a front view of the same overboot sectioned on the line III—III of Figure 2,

Figure 4 is an expanded view of a sectioned part of the overboot shell of Figure 3,

Figure 5 is a diagrammatic illustration of the structure of the deflector prism of Figure 3, and

Figure 6 is a chart illustrating the relative effectiveness of various deflector prisms.

The overboot illustrated in Figures 1 to 3 comprises a platform sole 1 bonded to an overboot shell 2 provided with straps 3 for fastening the sole 1 beneath a conventional boot 4.

The sole 1 has a lower face 5 and an upper face 6 from which face 6 depends a hollow composite, triangular blast deflector prism 7 (Figures 2 and 3) having a base 8 which defines substantially the whole of the said face 6 and is integrally bonded to a sole face 9 of the overboot shell 2.

The prism 7 is of isosceles cross-section having symmetrical side faces 20 and 21 defining an apex 22 of angle α directed towards the lower face 5. Within the prism is a vertical brace 23 and a "V"-section metal capping strip 24 located adjacent the apex 22.

The twin cavities within the prism 7 are each filled with a core 25 formed from an energy absorbent material and the side faces 20 and 21 are embedded in a moulded surround 26 of a readily disruptable material that will offer minimum resistance to blast, eg a polyurethane foam. An outer layer 27 of non-slip material is attached to the lower face 5 of the surround 26 and extends upwardly onto the front and back faces of the surround.

A preferred integral structure for the composite deflector prism 7 and the overboot shell 2 will now be described with reference to Figures 4 and 5. The prism illustrated in expanded form in Figure 5 is constructed from laminate of resin impregnated fabric woven from fibres having a high strength and flash resistance, eg aramid fibres such as Kevlar (Registered Trade Mark). Fabrication is accomplished by first cutting and shaping the two cores 25 from a rigid foam of a plastics material having high crush resistance and heat resistance, eg polymetharcylicimide. Each of the cores 25 is then tightly wound with several laminates 40 (only one of which is shown for clarity) of the resin impregnated fabric. The two bound cores are then placed back to back to form a single prism having an integral "T"-brace 23, held firmly together under pressure and heat cured.

The resulting prism is then used as a former upon which further laminates 41 of the resin impregnated fabric are tightly wound until the required thickness has been built up, a stainless steel "V"-plate comprising the capping strip 24 being interleaved at the apex 22 adjacent the outermost layers.

The upper face 8 of the resulting prism is then pressed against the sole face 9 of the overboot shell 2 which shell has been similarly fabricated, as shown in Figure 4, from laminates 50 of the same resin impregnated fabric formed to appropriate shape on a wooden former 51. The straps 3 (shown in Figures 1 to 3) are interlayered with the laminates 50 during the laying up process. Two or more final laminates 52 are then lapped over the laminates 41 and 50 conjointly and the whole assembly held firmly together under vacuum and heat cured.

Various values for the apex angle and consequent height of the deflector prism 7 will provide varying degrees of protection, as previously discussed. So too will varying materials and prism structures. The graph illustrated in Figure 6 shows the comparative results of tests made using prisms of various apex angles and materials, the test prisms being loaded with a standard body weight and driven upwards in a vertical test frame by means of a standard underlying explosive charge. The column heights shown in the graph are indicative of the relative vertical displacements that were engendered.

Column 1 represents, for comparison purposes, a simple flat plate of 6mm mild steel and the remaining columns represent prisms of the following form:

3. Solid aluminium with 90° apex angle
4. Solid aluminium with 45° apex angle
5. Kevlar with 90° apex angle, without "T"-brace
6. Kevlar with 90° apex angle, with "T"-brace
7. Kevlar with 45 apex angle, with "T"-brace
8. Kevlar with 45 apex angle, with "T"-brace and aluminium capping strip
9. Kevlar with 45 apex angle, with "T"-brace and stainless steel capping strip.

It will be seen from these results that the prism of the previously described preferred embodiment provides the best protection of all those tested. This embodiment has been found adequate, in other more advanced tests with simulated limbs, for reducing the injury sustained to a repairable level.

The preferred embodiment may also be advantageously provided with an additional layer of energy absorbing foam (not shown) laid interjacent the wearer's own boot sole and the overboot shell.

CLAIMS

1. Protective footwear for protection against subjacent explosive blast including a platform sole having an upper face, a substantially parallel lower face and a blast deflector disposed therebetween, the blast deflector being comprised by a triangular prism having a base located adjacent the upper face so as to extend longitudinally through substantially the full length of the sole and laterally through substantially the full width of the sole, having two equal length sides directed downwardly towards an apex, which apex extends longitudinally adjacent the lower face.

2. Protective footwear as claimed in claim 1 wherein the deflector prism has an apex angle no greater than 90°.

3. Protective footwear as claimed in any of the preceding claims wherein the deflector prism is a fibre reinforced plastics composite.

4. Protective footwear as claimed in claim 3 wherein the composite prism is tubular.

5. Protective footwear as claimed in claim 4 wherein the composite prism contains a multiplicity of hoop-wound circumferential fibres.

6. Protective footwear as claimed in claim 5 wherein the composite prism additionally contains a multiplicity of longitudinal fibres.

7. Protective footwear as claimed in claim 6 wherein the composite prism comprises a heat-cured laminate of resin impregnated woven fabric, the fabric being wound around the longitudinal axis of an appropriate former.

8. Protective footwear as claimed in any of claims 4 to 7 wherein the composite prism includes throughout its length a brace extending perpendicularly from the base to the apex.

9. Protective footwear as claimed in any of claims 4 to 8 wherein the composite prism additionally contains throughout its length a metal capping strip disposed adjacent the apex.

10. Protective footwear as claimed in any of claims 4 to 9 wherein the interior of the prism is filled with an energy absorbent plastics material.

11 Protective footwear as claimed in any of the preceding claims wherein the deflector prism is embedded in a disruptable plastics material surround defining the sides and lower face of the platform sole.

12. Protective footwear as claimed in any of the preceding claims wherein the platform sole is attached to an overboot shell.

13. Protective footwear substantially as hereinbefore described with reference to the accompanying Figures 1 to 5.

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